

THE NONOPERATIVE REHABILITATION OF A TRAUMATIC COMPLETE ULNAR COLLATERAL LIGAMENT TEAR OF THE ELBOW IN A HIGH SCHOOL WRESTLER: A CASE REPORT

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ABSTRACT

Background and Purpose: Injuries frequently occur in competitive wrestling, with the elbow joint representing about 25% of all injuries. Specific to the elbow, the ulnar collateral ligament (UCL) can be injured traumatically from takedowns in wrestling. In athletes with complete UCL tears, surgical management is often recommended with nonoperative management resulting in less favorable outcomes. The purpose of this case report is to present a nonoperative criterion-based rehabilitation program for a high school wrestler with a complete UCL tear of the elbow.

Case Description: A 17-year-old male wrestler presented to outpatient physical therapy with a complete UCL tear sustained from falling on an outstretched hand during a wrestling match. He presented with limited elbow range of motion (ROM), medial elbow instability, and weakness of the involved shoulder and forearm musculature. A three staged criterion-based rehabilitation protocol was developed for this subject based on specific criteria, including pain, elbow ROM, arm strength, and functional outcomes.

Outcomes: The subject was treated for nine visits over six weeks, and demonstrated improvements in all strength tests of the involved upper extremity, with elbow flexion strength improving the most by 58%. Return to sport (RTS) tests were used to assess the subject's ability to return to practice. At approximately eight weeks after initial injury, the subject was able to return to full participation in competitive wrestling with no reports of elbow pain or instability.

Discussion: Through the utilization of a criterion-based rehabilitation protocol for the nonoperative management of an UCL injury, this high school wrestler was able to safely progress back to wrestling without pain or instability in an accelerated time frame. Previously, no detailed rehabilitation guidelines for nonoperative management of UCL injuries in contact sports have been described. Additionally, few studies exist which report on the inclusion of RTS testing following an injury to the UCL of the elbow, as RTS testing is optimal for determining readiness for sport.

Level of Evidence: 4, Case Report

Key Words: Elbow, Ulnar Collateral Ligament, Return to Sport, Movement System

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BACKGROUND AND PURPOSE:

Injuries to the ulnar collateral ligament (UCL) in athletic competition have become increasingly recognized in the last two decades, with a high incidence in throwing athletes, due to the repetitive valgus stress to the medial elbow.¹⁻⁴ Traumatic injury to the UCL can also occur in sports such as wrestling and gymnastics.^{5,6} In a recent epidemiological study of collegiate athletic injuries, the highest rate of severe UCL injury occurred in wrestling (17.3/10,000 athletic events).⁷ Elbow injury rates among collegiate wrestlers have been reported to account for up to 28% of all injuries sustained, with UCL tears the most common diagnosis.²

The UCL functions to stabilize the medial elbow.⁵ This ligament is made up of 3 bundles, with the anterior bundle serving as the primary restraint to valgus stress and providing rotational stability.⁵ When contacting the ground with the elbow in extension, the UCL is the primary static restraint to elbow valgus and the external rotary moment placed on the joint.⁵ In combat sports like wrestling, athletes can land in this position throughout training and competition, putting them at risk for injury, which can range from capsuloligamentous sprains to complete ligament tears at the elbow.^{2,3} Cadaveric studies have demonstrated that with an elbow hyperextension injury, the elbow sustains a consistent pattern of injury which includes tearing of the anterior joint capsule and UCL, as well as potential rupture of the wrist flexor and pronator muscles.⁸

Diagnosis of UCL injuries is typically made through diagnostic imaging, via magnetic resonance imaging (MRI), magnetic resonance (MR) arthrogram, and/or ultrasound (US).⁹⁻¹¹ Physical examination will often reveal tenderness at the medial epicondyle, with valgus laxity and/or pain with clinical testing.^{9,10,12-14} Associated pathology can include soft tissue injury to the flexor pronator mass due to its anatomical relevance to the UCL, in addition to symptoms of ulnar neuropathy.⁹

Management of UCL injuries in athletes consists of either conservative or surgical options. Surgical reconstruction is most common for athletes in high levels of competition, especially in overhead athletes.^{9,15,16} Several surgical UCL reconstruction approaches have been described in the literature, of which most commonly harvest the palmaris longus tendon with or without ulnar nerve transposition.¹⁷

A systematic review by Watson et al.¹⁸ found varying outcomes based on the available techniques, with return to sport (RTS) percentages ranging from 62-92%. Surgical complications following this procedure have also been reported to be as high as 20%.^{17,19} The nonoperative management of UCL injuries has garnered less attention in the literature. Typically, nonoperative treatment is recommended for athletes with partial UCL tears or sprains.⁹ Results of nonoperative treatment are generally poor in overhead athletes, with a 42-50% RTS rate over a reported follow-up range of 13-54 weeks.²⁰ More recently, Dodson et. al²¹ reported successful nonoperative rehabilitation in nine out of 10 National Football League (NFL) quarterbacks with a mean RTS time of 26.4 days. However, three of the participants were classified as having a complete (Grade 3) UCL rupture, and averaged significantly longer (mean 67.3 days) RTS time.²¹ Nicolette and Gravlee⁶ reported a successful return to full competition with a nonoperative approach in four out of five Division 1 gymnasts with UCL tears. Three of the four gymnasts in this case series had a Grade 2 injury or greater with a mean RTS time of approximately 10 weeks.⁶ Outcomes from these studies suggest that the demands of the sport (overhead athlete vs. non-overhead athlete) could have an impact on time to return to sport.

The biomechanics of throwing have been well described in literature, with the UCL being placed under the most stress during the late-cocking/early acceleration phase.^{4,22,23} Biomechanical demands of wrestling maneuvers are less commonly studied, however traumatic contact injuries are the most common mechanism for UCL injury in this population.² Pasque and Hewett²⁴ reported that injuries in wrestling often occur during a takedown maneuver, with the defensive wrestler at greater risk, due to the intense nature of this action. Further, they postulated that due to the various takedown and defensive maneuvers available to wrestlers, it is difficult to accurately calculate the forces that are exerted on the upper extremity.²⁴ Injury risk is greater during matches than practices due to the inherent nature of wrestling competition.^{2,25}

The purpose of this case report is to present a non-operative criterion-based rehabilitation program for a high school wrestler with a complete UCL tear of the elbow.

CASE DESCRIPTION

A 17-year-old male (body mass index 23.41 kg/m²; weight class 160 pounds) presented to an outpatient physical therapy clinic with complaints of right (dominant side) elbow pain which began approximately 2.5 weeks prior. The subject stated that he was participating in a high school wrestling tournament when he was taken down during a match and fell on an outstretched hand, causing his right elbow to hyperextend upon landing. The match was immediately stopped by the match official due to the injury. The subject reported experiencing immediate pain and swelling at his right elbow, and was temporarily unable to bend his elbow. He was taken to a local emergency department where radiographs were taken. The results of the radiographs were inconclusive due to the amount of swelling, and his right upper extremity was immobilized in a sling. He underwent an MRI the following day, which revealed a complete tear of the ulnar collateral ligament, partial thickness common flexor tendon tear, possible radial head buckle fracture with radial neck and lateral humeral condyle contusion injuries, and low-grade partial thickness tears of pronator teres and flexor digitorum superficialis (Figure 1). The subject

followed up with an orthopedic physician three days after the initial injury. The orthopedist discontinued the sling immobilization, prescribed right elbow active range of motion (ROM) exercises to tolerance for home, and referred the subject to physical therapy. The subject was informed that the data concerning his case would be submitted for publication, and permission was granted by both he and his parent.

Examination Findings

The subject presented to outpatient physical therapy 18 days after the initial injury. He completed the Disabilities of the Arm, Shoulder, and Hand (DASH) questionnaire, and initial self-report pain values were recorded using the numeric pain rating scale (NPRS) (Table 1). Past medical history revealed multiple prior elbow hyperextension injuries to both the involved (2) and uninvolved (1) upper extremities from wrestling over the past three years. The subject stated that his prior injuries to both the involved and uninvolved elbows were treated conservatively with rest. He denied any prior neck, shoulder or wrist injuries. The subject was not taking any over-the-counter or prescription medication, and he reported no other significant past medical history. Upon observation, the subject had no visible deformities of the upper extremity, but held his involved elbow in approximately 90 degrees of flexion using the support of his non-involved arm. Skin was intact without any erythema or trophic changes. Sensation was grossly intact and capillary refill testing was normal to the right upper extremity. Reflex testing and

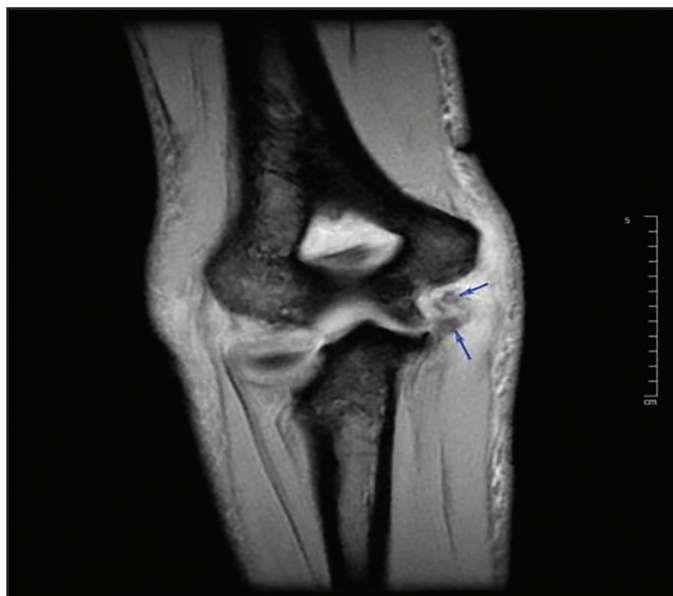


Figure 1. T1 Magnetic Resonance Imaging (MRI) with report which revealed a complete UCL tear (blue arrows) 2) Partial-thickness common flexor tendon tear, 3) Possible radial head buckle fracture with radial neck and lateral humeral condyle contusion injuries, 4) Low-grade partial-thickness tears of the pronator teres and flexor digitorum superficialis.

Table 1. Comparison of patient self-report pain rating and standardized outcome measures from initial physical therapy evaluation to discharge (6 weeks).

	Initial Evaluation	Discharge (6 weeks)
Pain at worst right elbow	8/10	0/10
Pain at best right elbow	5/10	0/10
Pain at present right elbow	6/10	0/10
DASH Score	17.5	0
DASH Sport Score	100	0
CKCUES- Test	-	31 repetitions
CKCUES Test, Closed Kinetic Chain Upper Extremity Stability Test; DASH, Disabilities of the Arm, Shoulder, and Hand		

Table 2. Improvement in elbow active range of motion in degrees from initial evaluation to discharge (6 weeks).				
	Right Elbow		Left Elbow	
	Initial	Discharge	Initial	Discharge
Flexion	128*	137	138	138
Extension	-7*	0	0	0
Supination	75*	87	88	88
Pronation	81	84	86	86
* Pain at end range				

upper limb tension tests were not performed due to location and acuity of injury.

Upon palpation, there was tenderness noted across the right medial humero-ulnar joint line and bony landmarks, including the radial head, medial epicondyle, coronoid process, and olecranon process. The subject was tender to palpation across his right elbow flexor/pronator mass, triceps and biceps brachii tendons with muscle guarding present. Girth measurements for swelling taken at the level of the elbow joint were 32.3 cm on the right and 31.6 cm on the left. A ROM assessment was performed with no significant motion restrictions or reproduction of symptoms in the subject's cervical spine, shoulders, or wrists. Right elbow active and passive ROM was noticeably restricted with an empty end feel for all end ranges. The greatest elbow ROM limitations were in flexion and extension respectively (Table 2). Elbow joint stability tests were performed and were positive for laxity and/or pain with valgus loading to the involved extremity (Table 3). A strength assessment was performed using a hand-held dynamometer which revealed significant deficits primarily with right grip strength and elbow flexion respectively (Table 4). Overall, the subject's presentation of medial elbow instability with associated swelling and concomitant loss of elbow ROM and strength was consistent with his orthopedic physician's diagnosis and

Table 3. Elbow joint special testing comparison from initial physical therapy evaluation to discharge (6 weeks).				
	Right		Left	
	Initial	Discharge	Initial	Discharge
Moving Valgus Stress Test	Positive * †	Positive †	Negative	Negative
Valgus Stress Test	Positive †	Positive †	Negative	Negative
Milking Sign	Positive *	Negative	Negative	Negative
* Positive for pain; † Positive for joint laxity				

Table 4. Strength assessment in kilograms via hand held dynamometry from initial physical therapy evaluation to discharge (6 weeks).						
	Right (kgs)			Left (kgs)		
Action	Initial	Discharge	% Change	Initial	Discharge	% Change
Grip Strength	40.8	47.6	16.7%	43.3	48.5	12%
Elbow flexion	13.6	21.5	58%	15.5	18.3	15.3%
Elbow extension	18.6	21.3	14.5%	19.2	22.2	15.6%
Shoulder ER	10.9	13.2	19.8%	11.8	12.5	5.9%
Shoulder IR	16.7	19.9	19.2%	17.9	19.1	6.7%
Shoulder Flexion	21.8	27.7	27.1%	21.2	25.4	19.8%
ER, external rotation; IR, internal rotation; kgs, kilograms						

MRI findings. Examination results were discussed with the subject and his parent/guardian. Given that the subject's goal was to compete in his high school district's wrestling tournament in eight weeks, the subject, guardian, and physician had agreed to trial a course of nonoperative treatment without undergoing surgery. A comprehensive physical therapy treatment plan based on the subject's goals for return to wrestling was developed utilizing a criteria-based progression (Table 5).

Interventions

In this case report, physical therapy initially progressed the subject from weeks two to three post injury, gradually restoring elbow active ROM and promoting tissue healing and collagen reformation.^{26,27} Strengthening exercises in this phase included the elbow flexor-pronator group, which has been shown to contribute to stability of the medial elbow.²⁸ Additional strengthening addressed the elbow extensors, rotator cuff musculature, periscapular muscles, and the muscles of grip/mass grasp. In addition to the importance of these muscles on upper extremity function, stronger grip strength has been shown to be correlated with improved sport performance in wrestlers.²⁵ Cryotherapy was applied as needed at conclusion of each visit. Criteria for advancing to the next phase of rehabilitation included full, pain-free elbow flexion with minimal elbow joint swelling, as well as low (< 3/10) pain levels with strengthening exercises.

The second phase of rehabilitation, which began at approximately four to five weeks following the initial injury, progressed to include plyometrics and advancement of total arm strength. Plyometric

Table 5. *Rehabilitation criteria protocol.*

	Rehabilitation Goals	Interventions	Criteria for Progression
Phase 1	<ol style="list-style-type: none">1. Restore elbow AROM and PROM2. Decrease elbow joint swelling3. Initiate total arm strengthening while minimizing valgus stress at the elbow4. Protect healing tissues	<ol style="list-style-type: none">1. AROM/PROM to involved and surrounding joints2. Resisted wrist flexion/extension, pronation/supination3. Rotator cuff and periscapular strengthening4. Grip strengthening5. Manual therapy and instrument assisted soft tissue mobilization to relevant elbow soft tissue6. Cryotherapy	<ol style="list-style-type: none">1. Full pain free elbow AROM/PROM2. Minimal elbow swelling3. Pain rating <3/10 with strengthening exercises
Phase 2	<ol style="list-style-type: none">1. Increase total arm strength and endurance2. Initiate plyometric neuromuscular control exercises3. Prepare athlete for Return to sport activities	<ol style="list-style-type: none">1. Progressive elbow, shoulder, scapular, and grip strengthening2. CKC weight bearing (Partial to full)3. Open chain and partial weight bearing UE plyometrics	<ol style="list-style-type: none">1. Achieve 90% elbow flexion/extension strength symmetry compared to the uninjured side2. No elbow pain with closed kinetic chain exercises3. Pain rating 0/10 with all functional activities and ADL's4. DASH score <5
Phase 3	<ol style="list-style-type: none">1. Initiate sport specific exercises2. Improve neuromuscular control of affected UE3. Prepare athlete to return to sport activity	<ol style="list-style-type: none">1. Full weight bearing UE plyometrics on stable and unstable surfaces2. Upper extremity stability in full weight bearing3. Sport specific exercises including controlled falls and take-down maneuvers	<ol style="list-style-type: none">1. Achieve 90% limb symmetry with functional testing (YBT- UQ test)2. Achieve score ≥ 30 on CKCUEST3. No elbow pain or subjective complaints of instability with plyometric exercises4. Absence of elbow pain, instability or soreness with wrestling practice5. DASH Sport score <5
ADL, activities of daily living; AROM, active range of motion; CKC, closed kinetic chain; CKCUEST, closed kinetic chain upper extremity stability test; DASH, Disabilities of the Arm, Shoulder, and Hand; PROM, passive range of motion; UE- upper extremity, YBT-UQ, Y balance test-upper quarter			

exercises initially began in a closed-kinetic-chain position in partial weight bearing, and were progressed gradually into full single arm weight bearing on stable and unstable surfaces (Figures 2 and 3). Criteria for advancing to the third phase of rehabilitation, return to sport training, included the subject achieving 90% limb symmetry for elbow strength. Limb symmetry indices have been used as reliable progression criteria in lower extremity injuries, typically utilizing a less than 10% difference between sides in strength and functional testing.²⁹ Because limb symmetry indices have been shown to potentially overestimate

function in post-operative lower extremity injuries,³⁰ a 90% index was used as minimum criteria for progression in this current case.

The return to sport phase was initiated at approximately six weeks following the initial elbow injury. In this phase, the subject began sport specific training for wrestling in preparation to practice with his team. Exercises included dynamic loading of his affected upper extremity in varying degrees of elbow flexion, extension, pronation, and supination, progressing the affected elbow's ability to absorb a takedown



Figure 2. Single arm stability on a foam pad.



Figure 3. High plank shoulder taps on a foam pad.

maneuver in a match (Figures 4-6). The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) and the Y-Balance Test Upper Quarter (YBT-UQ) were utilized as functional tools to assess readiness for return to sport. The CKCUEST has been shown to be a reliable and valid measure to assess upper limb stability.³¹ A minimum score of 30 repetitions on this test was used as a requirement to return to sport, based on normative data in overhead throwers.³² This criterion was used due to the high impact demands of the sport, the severity of subject's injury, and his history of previous elbow injuries, as normative data in different athlete populations vary.³²⁻³⁵ The YBT-UQ has also been proven to assess dynamic upper quarter

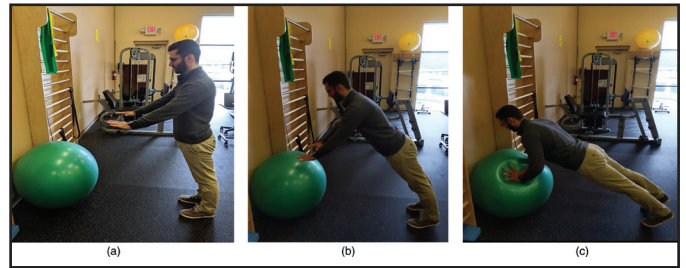


Figure 4. Controlled fall pushup. (a) The athlete begins the controlled fall with elbows extended and a physio ball safely secured against a surface. (b) The athlete begins to accept his body's weight onto the physio ball, landing with slight elbow flexion. (c) The athlete controls the fall through a pushup maneuver onto the physio ball.

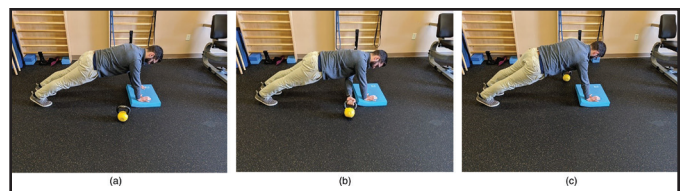


Figure 5. High plank stability with weight pull. (a) The athlete begins in a high plank position on a foam (unstable) surface. A weighted object (kettlebell) is underneath the upper extremity of the stabilizing arm. (b) While stabilizing on the affected upper extremity, the opposite upper extremity horizontally adducts and reaches for the weight while maintaining proper plank alignment. (c) The weighted object is pulled through horizontal abduction to the opposite side. It is then repeated with the other arm back to starting position.

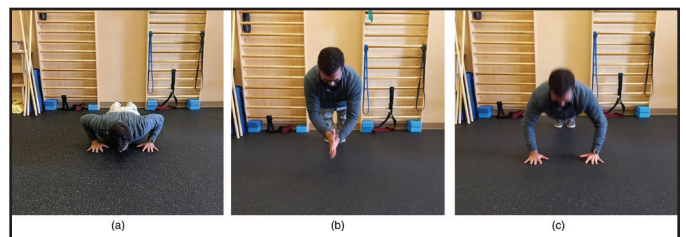


Figure 6. Plyometric push ups. (a) The athlete begins in the pushup position as pictured. (b) The athlete then produces a powerful movement to push his body upwards, allowing his upper extremities to leave the floor. While in the air, he performs a clap with his hands. (c) The athlete then lands his hands back on the floor, with varying degrees of elbow flexion required to stabilize his body.

stability.³⁴ A 90% limb symmetry index on the YBT-UQ was also used as a minimum criterion for progression to return to sport, similar to the strength index in the prior phase.

Explanation of Exercise Dosage

The description and exact dosage of exercise intensity, frequency and duration varied throughout each phase of exercise. In the early phase, dosage of exercise remained comparatively lower than in later phases due to the acuity of elbow injury, and pain. Overall Phase 1 training volume and resistance of exercise was low to moderate (1-3 sets, 6-10 repetitions), and was based on pain levels (<3/10), and rate of perceived exertion (RPE) (<6/10). As the subject progressed through each phase, training volume resistance was increased to moderate to high levels (3-5 sets, 6-15 repetitions), as this has shown to improve strength compared to lower dosages.³⁶ In later phases of rehabilitation (Phases 2 and 3), resistance was based on repetitions in reserve (RIR). As an example of how this scale was utilized, the subject was asked how many more repetitions he could perform at the conclusion of a set of a particular exercise. If the subject responded that he could perform zero to one more repetition of the exercise (0-1 RIR), this would indicate that the exercise required maximum effort. If the subject answered that he could perform four or more repetitions (>4 RIR), then resistance or difficulty was adjusted so that he felt that he could perform less than 4 RIR. The dosage of exercise varied based on the goal of the exercise (strength, power, endurance).³⁷

The subject also performed a home exercise program two times per week to supplement his one to two times per week of formal physical therapy. These exercises were primarily strength based, and were adjusted throughout his course of rehabilitation in order to be consistent with the goals of each phase.

OUTCOMES

The subject was seen in physical therapy for a total of nine visits over six weeks. Table 4 presents the subject's strength assessment measurements at discharge, with an improvement noted in all strength measures in both the affected and unaffected extremity. Elbow flexion strength demonstrated the greatest improvement from baseline to discharge (7.9 kgs), followed by grip strength (6.8 kgs) in the affected upper extremity. The DASH questionnaire and the DASH Sport Score improved significantly (based on the minimal clinically important difference of 10.8 points³⁸) from initial examination from 17.5 and 100,

Table 6. Patient results of the YBT-UQ taken at discharge (6 weeks) (Limb Length- 84.4 cm).			
YBT-UQ Test Components	Right	Left	LSI %
Medial	87.6cm	85.5cm	102.4
Inferolateral	76.2 cm	71.6 cm	106.4
Superolateral	51.8 cm	46.8 cm	110.6
Total Excursion	215.6cm	193.4cm	111.4
Composite Score	85.2	80.5	105.8
cm, centimeter; LSI, limb symmetry index; YBT-UQ, Y Balance Test-Upper Quarter			

to 0 and 0 respectively. The subject's performance on the CKCUEST at discharge was similar to those reported in healthy overhead throwing athletes (Table 1.³²) The results of the YBT-UQ results were also similar when comparing the involved and uninjured upper extremity (Table 6).^{34,39} Joint integrity tests at discharge were only found to be positive for right elbow laxity with the valgus stress tests (Table 3). The subject denied any right elbow pain at rest or with return to sport testing at discharge.

Following discharge from physical therapy, the subject began participating in wrestling practices with his high school team. Training load in practice was monitored by his athletic trainer, and participation in competitive matches was reached at approximately 1.5 weeks upon returning. Approximately two weeks after discharge, the Subject began experiencing increased soreness in his affected elbow. Upon recommendation from the physical therapist and athletic trainer, the subject began using an elbow stability brace (DonJoy Bionic Elbow Brace II, Dallas, TX) to support him during competition. The subject was able to successfully participate in matches and his district tournament without any soreness, pain, or complaints of instability to his right elbow. During a phone conversation three months after discharge, the subject expressed he had elected not to undergo surgery, and continued to train in preparation for college participation without any issues.

DISCUSSION

This case report highlights the successful non-operative rehabilitation program of an in-season high school wrestler with a traumatic complete UCL tear at the elbow. A criterion-based physical therapy program was utilized which progressed the subject through elbow ROM, progressive strengthening,

and sport-specific training. No detailed rehabilitation guidelines for nonoperative management of UCL injuries in contact sports have previously been described in the literature. Therefore, the physical therapy program utilized in this case report was based on prior published studies in an effort to return the subject to competitive wrestling.^{6,9,10,15,20,21,40}

Previous studies which highlighted nonoperative management for subjects with UCL tears have generally consisted of a short period of immobilization or bracing, ranging from two to six weeks, allowing for gradual increases in elbow ROM to tolerance.^{6,10,20,21} The subject in this case was immobilized for three days, which is much more progressive than what has been described in the literature with this type of injury. Through discontinuing the sling earlier post-injury, the subject was able to initiate ROM activities more quickly, which may have minimized impairments to his elbow ROM at his initial presentation to physical therapy. Utilization of non-steroidal anti-inflammatory (NSAIDs) medication or modalities have also been advocated in the early phase of recovery following this injury.^{10,21} The subject in this case report did not receive any medication for the management of pain, nor were any modalities utilized other than cryotherapy.

Following the initial period of immobilization, the interventions described in prior studies varied based on the reported subject population.^{6,10,20,21} Dodson et. al²¹ did not report any interventions beyond the initial phase of immobilization, NSAIDs, and ROM exercises in NFL quarterbacks. Rettig et. al²⁰ reported the use of a progressive strengthening program prior to returning athletes to throwing at three months, although no specific details for intervention timing, dosage, or targeted muscle groups were reported. Nicolette and Gravlee⁶ reported on the conservative management of UCL injuries in gymnasts with a strengthening program to target relevant elbow and shoulder muscle groups, however the timing of interventions was not reported. Additionally, no information was included regarding exercise dosage based on injury severity, criteria for progression to sport specific exercises, or return to sport testing.⁶

The inclusion of the description of exercise dosage is an important distinction in this case report

when compared to prior reports. In the early phases of physical therapy rehabilitation, exercise dosage remained less intense overall in order to assist with tissue healing and reduce swelling in this subject. Application of the RPE scale was used in this phase, along with pain and fatigue levels, as a way to monitor over exertion and maintain a conducive healing environment.⁴¹ In later phases of rehabilitation, the RIR scale was used in place of the RPE scale, as it has also been suggested to accurately gauge exercise intensity.⁴² In these phases, the subject had lower comparative pain levels and was beginning plyometric and return to sport activities. Therefore, in order to adequately challenge the subject, the clinician deemed the RIR scale could more adequately dose the subject's exercise intensity and volume, promoting strength, stability, and endurance. With these principles in mind, it is important to note that the exact amount of repetitions and sets changed both during and between physical therapy sessions.

Another unique feature of this case report is that it is the first to incorporate return to sport testing as part of the RTS criteria, as previous studies have lacked this important facet of RTS assessment. Relevant return to sport testing is crucial to provide the physical therapist with information for the clinical decision-making process. The use of these tests in wrestlers is particularly relevant, as both tests require the participant to display adequate strength and stability of both upper limbs for sport related tasks.

Limb symmetry indices were also included in the criterion-based progression for the athlete. In general, limb symmetry indices have been well researched in knee injuries, in particular referring to muscle strength, and functional testing.^{29,30,43-45} Using these principles, a 90% threshold criteria was utilized in this case as an objective means to determine readiness for sport. Further research on normative data may help to better quantify strength indices in athlete subgroups such as for wrestlers.

Upon completion of the rehabilitation protocol, the subject was able to resume full wrestling team activities at eight weeks, which was quicker in comparison to previous studies of complete UCL tears.^{6,10,20,21} In these studies, longer RTS rates were typically found in throwers when compared to non-throwers.^{6,10,20,21}

A shorter RTS rate in this case report may have been attributed to the shorter initial period of elbow immobilization. Additionally, the subject was braced when returning to wrestling, which may have provided increased stability of the elbow joint and allowed for less fear of reinjury by the subject.

LIMITATIONS

There is a general dearth of detailed research regarding nonoperative management of UCL tears, leaving a lack of structure to guide clinicians in the management of this population. Furthermore, there are no studies that discuss the correlation of upper extremity limb strength symmetry, or functional testing symmetry on readiness to return to sport. The lack of data tracking length of care before returning the athlete to their sport is also not well established with nonoperative management of UCL tears.

Additionally, in this case report, the athlete used a brace during competition, as he reported subjective improvements in stability with its use. The athlete did not perform any RTS testing while wearing his brace, giving the treating physical therapist no comparative data. It is therefore difficult to determine if the athlete would have been able to participate in the athletic competition without any instability while not wearing his brace. Consequentially, as this case represents a single athlete, it has limited generalizability.

CONCLUSION

This case report highlights the successful nonoperative rehabilitation of a traumatic UCL tear in a high school wrestler based on existing evidence and progressive integration of advancing sport specific skills. The use of specific criteria, (i.e. limb symmetry indices, plyometric progressions, RTS tests) to progress an athlete through a return to sport rehabilitation protocol should be emphasized in subjects with similar presentations and in future clinical trials. The interventions chosen in this report were based on general biomechanical and anatomic principles and adjusted accordingly to address the needs of a wrestling athlete.

REFERENCES

1. Zaremski JL, McClelland J, Vincent HK, Horodyski M. Trends in sports-related elbow ulnar collateral ligament injuries. *Orthop J Sports Med.* 2017;5(10):2325967117731296.
2. Goodman AD, Twomey-Kozak J, DeFroda SF, Owens BD. Epidemiology of shoulder and elbow injuries in National Collegiate Athletic Association wrestlers, 2009-2010 through 2013-2014. *Phys Sportsmed.* 2018;46(3):361-366.
3. Dizdarevic I, Low S, Currie DW, Comstock RD, Hammoud S, Atanda A. Epidemiology of elbow dislocations in high school athletes. *Am J Sports Med.* 2016;44(1):202-208.
4. Fleisig G, Chu Y, Weber A, Andrews J. Variability in baseball pitching biomechanics among various levels of competition. *Sports Biomech.* 2009;8(1):10-21.
5. Floris S, Olsen BS, Dalstra M, Søjbjerg JO, Sneppen O. The medial collateral ligament of the elbow joint: anatomy and kinematics. *J Shoulder Elbow Surg.* 1998;7(4):345-351.
6. Nicolette GW, Gravlee JR. Ulnar collateral ligament injuries of the elbow in female division I collegiate gymnasts: a report of five cases. *Open Access J Sports Med.* 2018;9:183-189.
7. Kay MC, Register-Mihalik JK, Gray AD, Djoko A, Dompier TP, Kerr ZY. The epidemiology of severe injuries sustained by National Collegiate Athletic Association student-athletes, 2009-2010 through 2014-2015. *J Athl Train.* 2017;52(2):117-128.
8. Tyrdal S, Olsen BS. Hyperextension of the elbow joint: pathoanatomy and kinematics of ligament injuries. *J Shoulder Elbow Surg.* 1998;7(3):272-283.
9. Raducha JE, Gil JA, Harris AP, Owens BD. Ulnar collateral ligament injuries of the elbow in the throwing athlete. *JBJS Rev.* 2018;6(2):e1.
10. Smucny M, Westermann RW, Winters M, Schickendantz MS. Non-operative management of ulnar collateral ligament injuries in the throwing athlete. *Phys Sportsmed.* 2017;45(3):234-238.
11. Wood N, Konin JG, Nofsinger C. Diagnosis of an ulnar collateral ligament tear using musculoskeletal ultrasound in a collegiate baseball pitcher: a case report. *N Am J Sports Phys Ther.* 2010;5(4):227-233.
12. Callaway GH, Field LD, Deng XH, et al. Biomechanical evaluation of the medial collateral ligament of the elbow. *J Bone Joint Surg Am.* 1997;79(8):1223-1231.
13. O'Driscoll SW, Lawton RL, Smith AM. The "moving valgus stress test" for medial collateral ligament tears of the elbow. *Am J Sports Med.* 2005;33(2):231-239.
14. Rossy WH, Oh LS. Pitcher's elbow: medial elbow pain in the overhead-throwing athlete. *Curr Rev Musculoskelet Med.* 2016;9(2):207-214.
15. Redler LH, Degen RM, McDonald LS, Altchek DW, Dines JS. Elbow ulnar collateral ligament injuries in

- athletes: Can we improve our outcomes? *World J Orthop.* 2016;7(4):229-243.
16. Langer P, Fadale P, Hulstyn M. Evolution of the treatment options of ulnar collateral ligament injuries of the elbow. *Br J Sports Med.* 2006;40(6):499-506.
17. Cain EL, Andrews JR, Dugas JR, et al. Outcome of ulnar collateral ligament reconstruction of the elbow in 1281 athletes: results in 743 athletes with minimum 2-year follow-up. *Am J Sports Med.* 2010;38(12):2426-2434.
18. Watson JN, McQueen P, Hutchinson MR. A systematic review of ulnar collateral ligament reconstruction techniques. *Am J Sports Med.* 2014;42(10):2510-2516.
19. Clain JB, Vitale MA, Ahmad CS, Ruchelsman DE. Ulnar nerve complications after ulnar collateral ligament reconstruction of the elbow: a systematic review. *Am J Sports Med.* 2019;47(5):1263-1269.
20. Rettig AC, Sherrill C, Snead DS, Mendler JC, Mieling P. Nonoperative treatment of ulnar collateral ligament injuries in throwing athletes. *Am J Sports Med.* 2001;29(1):15-17.
21. Dodson CC, Slenker N, Cohen SB, Ciccotti MG, DeLuca P. Ulnar collateral ligament injuries of the elbow in professional football quarterbacks. *J Shoulder Elbow Surg.* 2010;19(8):1276-1280.
22. Loftice J, Fleisig GS, Zheng N, Andrews JR. Biomechanics of the elbow in sports. *Clin Sports Med.* 2004;23(4):519-530, vii-viii.
23. Chu Y, Fleisig GS, Simpson KJ, Andrews JR. Biomechanical comparison between elite female and male baseball pitchers. *J Appl Biomech.* 2009;25(1):22-31.
24. Pasque CB, Hewett TE. A prospective study of high school wrestling injuries. *Am J Sports Med.* 2000;28(4):509-515.
25. Thomas RE, Zamanpour K. Injuries in wrestling: systematic review. *Phys Sportsmed.* 2018;46(2):168-196.
26. Yang G, Rothrauff BB, Tuan RS. Tendon and ligament regeneration and repair: clinical relevance and developmental paradigm. *Birth Defects Res C Embryo Today.* 2013;99(3):203-222.
27. Järvinen TA, Järvinen M, Kalimo H. Regeneration of injured skeletal muscle after the injury. *Muscles Ligaments Tendons J.* 2013;3(4):337-345.
28. Park MC, Ahmad CS. Dynamic contributions of the flexor-pronator mass to elbow valgus stability. *J Bone Joint Surg Am.* 2004;86(10):2268-2274.
29. Davies GJ, McCarty E, Provencher M, Manske RC. ACL return to sport guidelines and criteria. *Curr Rev Musculoskelet Med.* 2017;10(3):307-314.
30. Wellsandt E, Failla MJ, Snyder-Mackler L. Limb symmetry indexes can overestimate knee function after anterior cruciate ligament injury. *J Orthop Sports Phys Ther.* 2017;47(5):334-338.
31. Lee DR, Kim LJ. Reliability and validity of the closed kinetic chain upper extremity stability test. *J Phys Ther Sci.* 2015;27(4):1071-1073.
32. Roush JR, Kitamura J, Waits MC. Reference values for the closed kinetic chain upper extremity stability test (CKCUEST) for collegiate baseball players. *N Am J Sports Phys Ther.* 2007;2(3):159-163.
33. Negrete RJ, Hanney WJ, Kolber MJ, Davies GJ, Riemann B. Can upper extremity functional tests predict the softball throw for distance: a predictive validity investigation. *Int J Sports Phys Ther.* 2011;6(2):104-111.
34. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. *Int J Sports Phys Ther.* 2012;7(2):139-147.
35. Taylor JB, Wright AA, Smoliga JM, DePew JT, Hegedus EJ. Upper-extremity physical-performance tests in college athletes. *J Sport Rehabil.* 2016;25(2):146-154.
36. Ralston GW, Kilgore L, Wyatt FB, Baker JS. The effect of weekly set volume on strength gain: a meta-analysis. *Sports Med.* 2017;47(12):2585-2601.
37. Lorenz D, Morrison S. Current concepts in periodization of strength and conditioning for the sports physical therapist. *Int J Sports Phys Ther.* 2015;10(6):734-747.
38. Franchignoni F, Vercelli S, Giordano A, Sartorio F, Bravini E, Ferriero G. Minimal clinically important difference of the disabilities of the arm, shoulder and hand outcome measure (DASH) and its shortened version (QuickDASH). *J Orthop Sports Phys Ther.* 2014;44(1):30-39.
39. Butler RJ, Myers HS, Black D, et al. Bilateral differences in the upper quarter function of high school aged baseball and softball players. *Int J Sports Phys Ther.* 2014;9(4):518-524.
40. Wilk KE, Macrina LC, Cain EL, Dugas JR, Andrews JR. Rehabilitation of the overhead athlete's elbow. *Sports Health.* 2012;4(5):404-414.
41. Hampson DB, St Clair Gibson A, Lambert MI, Noakes TD. The influence of sensory cues on the perception of exertion during exercise and central regulation of exercise performance. *Sports Med.* 2001;31(13):935-952.
42. Helms ER, Cronin J, Storey A, Zourdos MC. Application of the repetitions in reserve-based rating of perceived exertion scale for resistance training. *Strength Cond J.* 2016;38(4):42-49.

-
43. Zwolski C, Schmitt LC, Thomas S, Hewett TE, Paterno MV. The utility of limb symmetry indices in return-to-sport assessment in subjects with bilateral anterior cruciate ligament reconstruction. *Am J Sports Med.* 2016;44(8):2030-2038.
44. Gokeler A, Welling W, Benjaminse A, Lemmink K, Seil R, Zaffagnini S. A critical analysis of limb symmetry indices of hop tests in athletes after anterior cruciate ligament reconstruction: a case control study. *Orthop Traumatol Surg Res.* 2017;103(6):947-951.
45. Rohman E, Steubs JT, Tompkins M. Changes in involved and uninvolved limb function during rehabilitation after anterior cruciate ligament reconstruction: implications for limb symmetry index measures. *Am J Sports Med.* 2015;43(6):1391-1398.